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ABSTRACT

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Abstract

The direction of subjects' first gaze shift following questions designed to elicit verbal-linguistic or visuo-spatial processing was examined in three experiments under video camera and face-to-face interview conditions. In all three experiments, verbal questions elicited significantly more downward gaze shifts than spatial questions. However, previous findings that verbal questions elicited more rightward gaze shifts than spatial questions were not replicated. These results appear to be incompatible with theories linking direction of gaze shifts with the functional asymmetry of the cerebral hemispheres. It was also observed that trials on which no gaze shifts were elicited occurred more often for spatial than for verbal questions.

EFFECTS OF VERBAL AND SPATIAL QUESTIONS ON INITIAL GAZE SHIFTS[1]

Howard Ehrlichman, Susan L. Weiner, and A. Harvey Baker[2]

Educational Testing Service

Communicative and affective features of gaze and gaze shifts in interpersonal situations have been the subject of much investigation (Exline, 1971; Kendon, 1967; Tomkins, 1963). However, recent studies have suggested that gaze shift may also reflect aspects of cognitive process. In particular, the lateral direction of gaze shifts which occur when a person is asked a question requiring reflective thought (Day, 1967; Duke, 1968; Libby, 1970) has been linked to the functional asymmetry of the cerebral hemispheres (Bakan, 1969, 1970; Kinsbourne, 1972; Kocel, Galin, Ornstein, & Merrin, 1972). It has been reported that people who consistently shift their gaze to the right differ from those who habitually shift their gaze to the left on a variety of personality, physiological and cognitive measures (cf. Singer & Singer, 1972). Bakan (1969, 1970) has interpreted these differences as reflecting differential reliance on the left or right hemisphere, i.e., the hemisphere contralateral to the usual direction of gaze shift. Kinsbourne (1972) and Kocel et al. (1972) have presented data which indicate that the direction of gaze shift may be influenced by the type of cognitive activity in which a person is currently engaged. These investigators have assumed, like Bakan, that gaze shift is controlled contralaterally. They have argued that if the left hemisphere is "activated" by material requiring processing for which it is specialized, gaze will tend to shift to the right. Likewise, if the right hemisphere is so activated, gaze will tend to shift to the left. Since in right-handed people the left hemisphere is associated with language processes and the right hemisphere with spatial-visualization processes (Galin & Ornstein, 1972;

Hécaen, 1962; Sperry, 1968), Kinsbourne and Kocel et al. predicted that, within subjects, questions which elicited language-related processing would lead to more rightward gaze shifts and questions which elicited spatial processes would lead to more leftward gaze shifts. These predictions were confirmed: right-handed subjects exhibited relatively more rightward gaze shifts for questions meant to elicit language processing than for questions meant to elicit spatial processing.

These results are of interest for several reasons. First, they render Bakan's analysis of differences between people who habitually exhibit left or right gaze shifts plausible by providing an empirical link between the direction of gaze shifts and hemispheric specialization. Second, Kinsbourne (1971) has interpreted these data as providing major support for a general model relating perceptual laterality effects and cerebral asymmetry of function (Kinsbourne, 1970). In its bare outlines, this model states that the asymmetrical activation of the hemispheres may lead to asymmetries in the deployment of attention in external space, and may even result in shifts in physical orientation contralateral to the preponderant hemisphere. Any evidence supporting this model merits serious consideration because the model provides a comprehensive and parsimonious explanation for the purported relationship between a wide variety of perceptual laterality effects and hemispheric specialization (cf. Ehrlichman, 1972; Kimura, 1966, 1967; Springer, 1971). Third, the putative relationship between the direction of gaze shift and hemispheric activation potentially allows investigators to use gaze shift behavior in studying hemispheric involvement in cognitive activities. For instance, it might be possible to use gaze shifts as indicators of the relative use of the verbal-left or the spatial-right hemisphere in various kinds of problem-solving tasks.

It had been our intention to employ gaze shift behavior as a means of studying hemispheric involvement in solving certain types of logic problems (Clark, 1969; Huttenlocher, 1968). However, a number of considerations led us to believe that a replication of the findings which linked type of question and direction of gaze shift was necessary. In particular, a post hoc analysis of an earlier study (Ehrlichman, 1972) indicated that spatial and verbal questions not only failed to elicit the predicted differences in gaze shift behavior, but also showed a nonsignificant difference in the direction opposite to that found by Kocel et al. and by Kinsbourne. A further reason was our concern with a discordant aspect of Kinsbourne's results. In addition to the differences in horizontal gaze shifts, he reported a difference in vertical gaze shifts: spatial questions elicited significantly more upward gaze shifts than did verbal questions. Kinsbourne did not attempt to integrate this vertical gaze shift difference into his theory of contralateral hemispheric activation. Indeed, it is difficult to see how such an integration could be effected. The inability of the theory of contralateral activation to account for the entire set of differences in gaze shifts obtained for verbal and spatial questions raises doubts about its explanatory power.

Because the type of question appears to affect the direction of gaze shifts in both the horizontal and vertical dimensions, classifying gaze shifts in mutually exclusive categories as Kocel et al. and Kinsbourne have done seemed inappropriate. Kocel et al. classified all gaze shifts to the right of the vertical midline as "right" and to the left as "left." Kinsbourne classified gaze shifts as either "right," "left," "up" or "down." Because of these differences in classification, a gaze shift scored by Kocel et al. as "right" might have been scored by Kinsbourne as "up."

Even within Kinsbourne's more differentiated system, no distinction is made between, for example, two gaze shifts classified as "right" even though one might be above and one might be below the horizontal midline. In order to avoid this type of arbitrary classification, the present experiments employ a new scoring system in which a centroid is used to summarize each subject's gaze shift behavior. This system allows both the horizontal and the vertical dimensions of each gaze shift to be represented in the subject's score.

The experiments described below attempted to replicate and extend the findings for both horizontal and vertical gaze shifts in response to questions intended to elicit verbal and spatial processing. It is clear that various types of questions can be classified as "verbal" or "spatial." There seems to be agreement between Kinsbourne and Kocel et al. as to what constitutes a "spatial" question, viz., any question which appeared to call for visuo-spatial processing or knowledge of spatial relations. However, their sets of "verbal" questions were radically different. Kocel et al. used questions which tended to call for numerical calculations or rote knowledge of the characteristics of English (e.g., conjugation of a verb, listing of parts of speech). Kinsbourne required subjects to elaborate the meaning of proverbs or to remember sentences after an interval in which they counted backwards. The mediating processes required for these sets of questions appear to be very different, even though they are in some way associated with words or with the language system. Because both of these sets of "verbal" questions are restricted in the kinds of processing they seem to require, the set of verbal questions used in the present studies was designed not only to include questions like those used by Kinsbourne and Kocel et al. but also to sample a wider range of language related processes.

In both Kinsbourne's and Kocel et al.'s experiments, the differences in gaze shifts between verbal and spatial questions were observed under conditions in which subjects faced a video camera. In contrast, the bulk of the research on gaze behavior has been carried out under conditions in which subjects faced another person (e.g., Bakan, 1969; Kendon, 1967). Because the effects of facing another person on gaze shifts in response to verbal and spatial questions were not known, the present studies used both video camera and face-to-face conditions.

Experiment I

Method

Subjects. Subjects were 34 paid adult volunteers recruited through an advertisement in a local newspaper. All Ss were right-handed (by self-report and observed writing hand). By a criterion described in the section on scoring of gaze shifts below, one S was dropped from the sample. Of the remaining 33 Ss, 17 were female and 16 were male.

Questions. A total of 80 questions were used, divided into two sets of 40 questions each: a "spatial" set intended to involve the right hemisphere and a "verbal" set intended to involve the left hemisphere. The spatial set consisted of questions designed to elicit various kinds of visual imagery and the use of spatial concepts.[3] Examples are: (a) "Try to form a mental picture of what I am going to tell you and tell me when the picture is as clear as you can get it: a poodle." (b) "How many angles are there in the Red Cross symbol?" (c) "If a person is facing the rising sun, where is south with respect to him?" (d) "Describe the route by which you came to ETS today." The verbal set consisted of questions designed to require the use of syntactic and semantic knowledge of language, along with a few logic

problems. Examples are: (a) "What is the definition of the word 'charity'?" (b) "There is something wrong with the following sentence. What is it? 'In the middle of hanging out the wash, the wind blew down the clothesline.'" (c) "What word is this the definition of: 'A large spotted animal with a long neck'?" (d) "Briefly, what is the meaning of this common proverb: 'Let sleeping dogs lie'?" (The entire list of questions can be found in the Appendix.)

The questions were divided into two blocks of 20 verbal and two blocks of 20 spatial questions each. Half the Ss received the questions in the block order VSSV; half received them in the order SVVS. Four different random orders of questions were used within each block. In addition, 40 "neutral" questions which did not appear to call primarily for verbal or spatial processing were presented. Examples are: (a) "What do you think about having a woman president?" (b) "Which planet is farther from the sun, Venus or Neptune?" (c) "What book have you enjoyed the most?" Twenty neutral questions were given at the beginning and 20 at the end of each session. These questions were included for reasons not germane to the present study, and therefore will not be discussed.

Procedure. S was seated in front of a table (48" x 60") alone in a small room (121" x 76"). Across the table, the lens of a video camera (Shibadden HV-15) appeared through a hole cut in a sheet of gray cardboard which hid the rest of the camera from view. The camera's distance from S was approximately four feet. Care was taken that no asymmetries existed in the physical arrangement of the room or in S's view. Communication with E, who observed S on a monitor in another room, was maintained through the use of a lavalier microphone around S's neck and a speaker located behind

the camera. All questions were prerecorded by both a male and female E. Sex of voice was balanced within sex of S.

Ss were told that the experiment involved the viability of automated procedures for experimental interviews. They were instructed to look into the camera so that E could be sure that S was prepared for the question. Ss were also instructed to continue looking into the camera during the time the question was asked but were told that looking into the camera at any other time was not necessary. This provided a centered gaze position from which to judge the direction of subsequent gaze shifts and also insured that Ss had heard the entire question before shifting their gaze. Ss were further told to sit comfortably without shifting to one side or another. Gaze shifts were scored by two Es. The entire session was recorded on video tape so that discrepancies between Es could be resolved.

Scoring system for gaze shifts. Each gaze shift was assigned a number from "1" to "12" corresponding to its direction on an imaginary clock face superimposed around each of S's eyes (see Figure 1). On those occasions when S moved his head, the clock faces were considered to move with the head rather than remain in a constant position. By this scheme, a score of "3" represents a direct leftward gaze shift. (In this paper, "left" and "right" always refer to S's left and right.) Trials on which no gaze shift occurred prior to completion of S's answer were designated as "stares." Occasionally, neither gaze shifts nor stares were observed because S shifted gaze prior to completion of the question ("no contact"), moved his head to a position in which his eyes were not visible ("head down" or "head turn"), or closed his eyes ("close"). Any S who exhibited these responses to more than 50% of the verbal or spatial questions was excluded from the data analysis.[4]

Insert Figure 1 about here

S's gaze shifts were summarized by two "centers of mass," one for verbal questions and one for spatial questions. The number of gaze shifts falling at each of the 12 clock face positions was tallied for each S for verbal and spatial questions separately. Graphically, S's center of mass can be understood as the centroid of the N data points, where N equals the number of gaze shifts. When plotted in polar coordinates, the distance from the origin (radius) of each gaze shift would correspond to the extent of the sweep of the gaze shift if such measurements were made (e.g., using an EOG). In that case, the center of the graph would correspond to instances of no gaze shift (i.e., stares). In the present case, certain constraints are placed on this scheme. Since no measurement of extent of gaze shift was made, the gaze shifts were treated as if they were all of the same extent. Thus, the lengths of the radii are equal and all data points lie on a circle. In addition, since each gaze shift was assigned one of 12 values, the maximum number of data points on this circle was 12. Each point (corresponding to a clock position) was weighted by the number of gaze shifts which occurred at that clock position. (These weights or counts may be thought of as extending into a third dimension perpendicular to the plane of the graph.) In calculating the center of mass, the cartesian coordinates of each data point (i.e., the projections of the point onto the X and Y axes) are multiplied by the number of gaze shifts at that position, are then summed across all data points, and are divided by the total number of gaze shifts. This results in a mean X

and mean Y which define the center of mass of the set of points. In actual practice, it is not necessary to plot data points. The X and Y coordinates of the center of mass are readily computed by the formulae:

(General case:)

$$X = \sum_{1}^{N} r_i \, (\cos \theta_i)/N$$

$$Y = \sum_{1}^{N} r_i \, (\sin \theta_i)/N$$

where: r_i = radius of gaze shift (i.e., extent of gaze shift)

θ_i = angle of gaze shift (i.e., direction of gaze shift)

N = total number of gaze shifts.

(Present case using clock face classification, i = 1 - 12, and treating extent of gaze shifts as a constant, $r_i = 1$:)

$$X = \sum_{1}^{12} n_i \, (\cos \theta_i)/N$$

$$Y = \sum_{1}^{12} n_i \, (\sin \theta_i)/N$$

where: n_i = number of gaze shifts at i o'clock

θ_i is measured in 30° increments starting at i = 3 o'clock and moving counterclockwise.

For i(1-5), cos is positive

For i(7-11), cos is negative

For i(10-2), sin is positive

For i(4-8), sin is negative.

In the present case, both X and Y can range from -1.0 to +1.0. For X, a positive value represents relatively more leftward gaze shifting (recall that "left" and "right" refer to S's left and right) and a

negative value relatively more rightward gaze shifting. For Y , a positive value represents relatively more upward gaze shifting, a negative value relatively more downward gaze shifting. The important point about this system is that each gaze shift is represented in the summary score according to the relative strengths of its horizontal and vertical components. Thus, a gaze shift of "4" will contribute more to the horizontal (X) component of the center of mass and less to the vertical (Y) component than will a gaze shift of "5". In this paper, the X and Y components of the center of mass were used as the basic units of analysis.[5]

Results

Since the hypotheses being tested involve a relative difference between gaze shifts for verbal and spatial questions, the sign of the mean X or mean Y component is not as critical as the direction of the difference between the types of questions for each component. This difference is expressed here as the mean score for verbal questions minus the mean score for spatial questions. Thus, a positive verbal minus spatial difference on the X component indicates relatively more leftward gaze shifting for verbal than for spatial questions, while a negative difference would indicate the opposite.

Insert Table 1 about here

The verbal minus spatial difference should be negative if verbal questions elicit relatively more rightward gaze shifts than do spatial questions, as has been reported by previous investigators. As can be seen

in Table 1, there was little difference observed in this experiment between verbal and spatial questions on the X component. Indeed, while nonsignificant, $t(32) = 0.76$, the direction of the difference is opposite to that found by Kinsbourne and Kocel et al. The means of X for verbal and spatial questions (shown in Table 1) both have a positive sign but are not significantly different from zero, verbal $t(32) = 1.01$, spatial $t(32) = 0.65$.

For the Y component, a positive verbal minus spatial difference indicates relatively more upward gaze shifting for verbal than for spatial questions, while a negative difference indicates the opposite. The verbal minus spatial difference should be negative if the present data follow the pattern reported by Kinsbourne for vertical gaze shifts. Table 1 shows that this was the case. The difference between verbal and spatial questions was negative and highly significant, $t(32) = 3.74$, $p < .001$. As can be seen in Table 1, the mean Y for verbal questions is negative. This value is significantly different from zero, $t(32) = 2.88$, $p < .01$. The mean for spatial questions, however, was small and positive and not significantly different from zero, $t(32) = 0.11$.

An unexpected feature of the results was the finding of a difference between verbal and spatial questions in the number of stares elicited. Significantly more stares occurred for spatial than for verbal questions (spatial Mean = 10.82, S.D. = 7.09; verbal Mean = 8.18, S.D. = 6.63), $t(32) = 3.87$, $p < .001$.

Experiment II

The results of Experiment I were surprising in two ways: first, we observed a strong vertical gaze shift difference between verbal and spatial

questions, a finding which had originally been treated by Kinsbourne as secondary; second, we did not find the difference in horizontal gaze shifts between question types which had been observed in two previous studies (Kinsbourne, 1972; Kocel et al., 1972).

Experiment II was carried out in order to examine further the pronounced vertical gaze shift finding and to explore a possible reason for the failure to find the horizontal gaze shift differences. Experiment II was like Experiment I except that a live experimenter replaced the video camera. This new procedure allowed the generality of the vertical difference to be tested in a face-to-face situation, conditions which have generally been used to study gaze shifts and their direction. In addition, the use of a face-to-face procedure eliminated one possible influence on Ss' gaze shift behavior: viz., the instruction in Experiment I that Ss look into the camera during the entire time the question was asked. This instruction seemed critical in order to provide a centered gaze position from which E could judge the initial gaze shift. Although no such requirement was specified by Kinsbourne and Kocel et al., our pilot studies using the video camera indicated that Ss tended to look away without necessarily returning to a centered gaze position before the end of the question. The face-to-face procedure in Experiment II enabled E to use eye contact with S to increase the chances that S's gaze would be centered at the end of the question and thereby eliminated the need for a possibly disruptive instruction.

Method

Subjects. Ss were 47 adult volunteers who were recruited through an advertisement in a local newspaper and who were right-handed by self-report and writing hand. Four Ss were dropped from the sample for failure

to meet the criterion established above. Of the remaining 43 Ss, 21 were male and 22 were female.

Procedure. The questions used in this experiment were those used in Experiment I, with the exception of two "humming" questions which were dropped in favor of two other questions requiring spatial visualization. The setting and procedure were like those in Experiment I except that a "live" E sat across the table from S. This E read the questions and recorded the direction of gaze shifts. Although no mention was made to S concerning looking behavior, E attempted to assure that eye contact existed at the end of the question. In order to avoid the possibility of experimenter bias under these conditions, two new Es (a female and a male), who were carefully kept blind to the purposes of the experiment, were used. Sex of S was balanced with respect to sex of E.

Results

Table 2 presents the means of the X and Y components and the verbal minus spatial differences for X and Y. For the Y component, the negative verbal minus spatial difference shown in Table 2 was significant, $t(42) = 5.16$, $p < .001$. Again, as in Experiment I, verbal questions elicited relatively more downward gaze shifts than spatial questions. The mean Y was negative and significantly different from zero for both verbal, $t(42) = 6.11$, $p < .001$, and spatial questions, $t(42) = 2.50$, $p < .02$.

Insert Table 2 about here

For the X component, the verbal minus spatial difference was positive, but not significant, $t(42) = 1.87$, $p < .07$. In this experiment, as in

Experiment I, the previously reported effects of type of question on the horizontal component were not found. Rather, a nonsignificant opposite pattern was again observed. As in Experiment I, the sign of X was positive but not significantly different from zero for both verbal, $t(42) = 1.45$, and spatial questions, $t(42) = 0.45$.

Unlike the results for stares in Experiment I, the number of stares in Experiment II did not differ for verbal and spatial questions (verbal Mean = 3.84, S.D. = 4.42; spatial Mean = 3.91, S.D. = 4.36), $t(42) = 0.21$. The number of stares overall was substantially less in this experiment, Mean = 7.74, S.D. = 8.51, than in Experiment I, Mean = 19.00, S.D. = 13.16, $t(74) = 4.52$, $p < .001$.

Experiment III

Both Experiments I and II failed to show an effect of question type on horizontal gaze shifts of the kind reported by Kocel et al. and Kinsbourne. Because the original phenomenon was observed in two independent studies, a final attempt to replicate seemed worthwhile, using procedures which more closely approximated those used in one of these studies (Kocel et al.). Thus, in order to minimize procedural differences, Experiment III excluded our neutral questions, included the questions used by Kocel et al. as well as our own, and also employed both video camera and face-to-face interview conditions for each S.

Method

Subjects. Ss were 43 adult right-handed volunteers. Five Ss were dropped from the sample because their eyes were not visible on at least 50% of the trials. Of the remaining 38 Ss, 20 were male and 18 were female.

Questions. Two groups of 40 questions were used: 20 verbal and 20 spatial questions used by Kocel et al. and 20 verbal and 20 spatial questions from those used in Experiments I and II. (The questions used in this experiment can be found in the Appendix.) Each set of 20 questions was further divided into two blocks of 10 questions each. Two random orders varied the sequence of questions within a block. Half the Ss received both Kocel et al.'s and our questions in the block order VSSV, half received them in the block order SVVS.

Procedure. The same room used in the previous experiments was used for both the video camera and face-to-face conditions. The procedure for the video camera condition was the same as in Experiment I except that the camera lens appeared between two curtains hung the length of the room behind the table. In the face-to-face condition, the curtains covered the camera so that it was not visible. In all other respects, the procedure in the face-to-face condition was the same as in Experiment II. The male E from Experiment II was used in this experiment. It was ascertained by extensive questioning both prior to and following this experiment that this E remained unaware of the purposes of the study. Each S served under both interview conditions, with a 20-minute break between them. Half of the Ss were run in the video camera condition first, half in the face-to-face condition first. Half of the Ss were asked Kocel et al.'s questions under the video camera condition and our questions under the face-to-face condition; for the other half the situation was reversed.

Results

Two 2 x 2 analyses of variance with repeated measures on both factors were carried out on the verbal minus spatial differences, one for the Y

component and one for the X component. For Y, there was a significant effect of source of question (i.e., Kocel et al.'s or ours), $F(1,33) = 7.92$, $p < .001$, but no effect of interview condition (video camera or face-to-face), $F(1,33) = 0.01$, or of the condition by source interaction, $F(1,33) = 0.46$. For X, neither source of question, $F(1,33) = 0.05$, interview condition, $F(1,33) = 0.02$, nor their interaction, $F(1,33) = 0.45$, was significant.

Insert Table 3 about here

Because the interactions were not significant, the differences between verbal and spatial questions were tested for the two interview conditions (collapsed across source of question) and for the two sources of questions (collapsed across interview condition) (see Table 3). For the Y component, the verbal minus spatial difference was again significant for our questions, $t(37) = 3.79$, $p < .001$. However, no difference was found for Kocel et al.'s questions, $t(37) = 0.28$. As indicated by the analysis of variance reported above, the difference between the mean verbal minus spatial differences for Kocel et al.'s and our questions was highly significant. Thus, the tendency for verbal questions to elicit relatively more downward gaze shifts than spatial questions holds for our questions, but not for Kocel et al.'s. The difference between Kocel et al.'s questions and our questions is attributable to differences between the verbal, $t(37) = 3.40$, $p < .002$, and not the spatial sets, $t(37) = 0.34$ (see Table 3).

As in Experiments I and II, the sign of the verbal minus spatial difference for the X component was positive, regardless of interview condition or source of questions. Again, none of the verbal minus spatial

differences for the X component was significant. Even with the same questions used by Kocel et al. the sign of the verbal minus spatial difference was opposite to what they reported. As before, none of the mean X components in Table 3 was significantly different from zero.

Consistent with the finding in Experiment I, more stares occurred in the video camera condition for spatial (Mean = 2.90, S.D. = 2.44) than for verbal questions (Mean = 0.90, S.D. = 1.77), $t(37) = 6.38$, $p < .001$. In contrast to Experiment II, however, a significant difference in the face-to-face condition for stares was also found between spatial (Mean = 2.00, S.D. = 2.23) and verbal questions (Mean = 1.21, S.D. = 2.60), $t(37) = 2.13$, $p < .05$. The number of stares for the video camera condition (Mean = 3.79, S.D. = 3.79) was not different from the number of stares in the face-to-face condition (Mean = 3.21, S.D. = 4.23), $t(37) = 0.64$.

Discussion

The present findings suggest the need for a revaluation of previous empirical and theoretical claims concerning the effects of type of question on gaze shifts. In previous studies of gaze shift, the horizontal component has been treated as the salient dimension. However, in the present experiments, it was the vertical component which reliably emerged as significantly affected by type of question. To the extent that the horizontal component showed any effects of type of question, these effects contradict the theoretical positions attempting to relate cerebral asymmetries to horizontal direction of gaze shift. In the following discussion, classes of explanations for the vertical gaze shift effect are considered and possible factors underlying the discrepancy between present and previous

results for horizontal gaze shifts are explored. The significance of the finding of differences in stare responses for the study of gaze shifts is also discussed.

Vertical Dimension of Gaze Shifts (Y Component)

In all three experiments, there were significant differences in the vertical direction of gaze shifts for our verbal and spatial questions: verbal questions elicited more downward gaze shifting than spatial questions. As mentioned earlier, Kinsbourne's original formulation does not seem capable of accounting for this finding. In order to integrate this result into a theory such as Kinsbourne's, one would have to postulate a control system for vertical gaze shifts based on particular loci in the brain. Although it is not impossible, for example, that the relatively posterior visual cortex "controls" upward gaze shifts while the relatively anterior speech cortex "controls" downward gaze shifts, we know of no evidence which suggests such cortical involvement in the control of vertical gaze shifts (Bach-Y-Rita, Collins, & Hyde, 1971). Because there is still much that is not known about the control of saccadic eye movements (Bach-Y-Rita et al., 1971), it seems premature to rule out entirely an explanation of gaze shift differences for verbal and spatial questions based on cerebral localization of activity. In any case, the particular positions put forth by Kinsbourne and Kocel et al. are inadequate to explain the present results.

There are, of course, other types of explanations of the vertical gaze shift phenomenon which are unrelated to notions of hemispheric specialization. Indeed, such explanations of gaze shifts may not directly involve the cognitive processes required by these questions. For example, it has been

noted that affective state influences the direction of gaze (Tomkins, 1963). Perhaps, in the present studies, differences in gaze shifts reflected differences in affect which were elicited by "noncognitive" variables such as degree of familiarity, novelty, etc. Similarly, gaze shifts have been found to be affected by social factors (e.g., Exline, 1971), and these also may have interacted with type of question.

Other interpretations might preserve the assumption that cognitive activity involved in answering the questions influences the direction of gaze shift, but in ways unrelated to particular hemispheric activity. For example, since the eyes tend to be directed downward in reading, it is possible that the repeated association between linguistic processes involved in reading and downward gaze transfers to the situation in which such processes are elicited by "verbal" questions.

Although these interpretations are clearly speculative, they illustrate that explanations of the observed differences in vertical gaze shifts between verbal and spatial questions can be derived from a variety of areas of research.

In any attempt to account for the present findings, it must be remembered that the labels "verbal" and "spatial" do not sufficiently specify the processes involved in answering these questions. The differences for the vertical component which were observed in Experiment III between Kocel et al.'s questions and our own illustrate the inadequacy of these terms. Recall that a significant difference was found between our verbal and spatial questions but that no such difference was found between Kocel et al.'s verbal and spatial questions. This was attributable to the significant difference between our verbal questions and Kocel et al.'s verbal questions.

This finding indicates that differences between our questions and those of Kocel et al. appear to have a real impact on the vertical component of gaze shifts, suggesting that the specific kinds of cognitive processes which a set of questions may elicit must be taken into account in any explanation of gaze shift behavior.

Horizontal Dimension of Gaze Shifts (X Component)

The results for horizontal gaze shifts in the three experiments were clearly at odds with those reported by Kocel et al. and Kinsbourne. Whereas the latter investigators found relatively more rightward gaze shifting for verbal than for spatial questions, no such difference was found in the present experiments. While the difference in the horizontal direction of gaze shifts observed by Kocel et al. and Kinsbourne was consistent with an interpretation based on the specialization and activation of the cerebral hemispheres (i.e., gaze shifts occurring in the direction contralateral to the activated hemisphere), data from each of the present experiments (as well as the data from the study in Ehrlichman, 1972) indicate a tendency for horizontal gaze shifts to be, if anything, ipsilateral to the hemisphere presumably involved (combining the values of t for these four studies yields a z of 2.45, $p < .02$). Since the original hypothesized association between gaze shift and hemisphere activated depended on the assumption of contralateral control, it is difficult to see how the present data could be explained by a theory emphasizing the role of cerebral asymmetry.

The question remains, however, as to how to account for the discrepancy between present results for horizontal gaze shifts and those of Kocel et al. and Kinsbourne. It seems reasonable that the sources of the discrepancy could be in differences in procedure and method, differences in subject

population, or some interaction of the two. It appears that the video camera procedures employed in the present studies were at least as similar to those of Kocel et al. as was Kinsbourne's procedure. Thus, it seems unlikely that procedure alone could be responsible for the discrepancy in findings. This notion is further supported by the fact that the same pattern of results obtained in the present experiments under different conditions (i.e., video camera and face-to-face). The possibility that differences in method of scoring could account for the discrepancy must also be rejected since similar results emerged when scores like those of Kocel et al. and Kinsbourne were used to analyze the present data.

If procedural differences were not responsible for the failure to replicate the horizontal gaze shift findings, differences in subject population may be. Although subject differences are obviously a very tentative explanation for the discrepancy in results, we have data which suggest that such differences may be important. In research concerning individual differences and direction of gaze shifts, we have found significant differences between relatively field-independent and field-dependent subjects (cf. Witkin, Dyk, Paterson, Goodenough, & Karp, 1962) in their relative direction of gaze shifts to verbal and spatial questions (Baker & Ehrlichman, in preparation). In the two samples analyzed to date,[6] relatively field-dependent Ss tended to show differences between verbal and spatial questions more in the direction found by Kinsbourne and Kocel et al. while relatively field-independent Ss tended to show differences more in the direction found in the present experiments, although in neither sample was the verbal minus spatial difference for field dependent Ss significantly different from zero.

The possibility that subject differences may act as moderator variables suggests that what appears to be unreliability in the horizontal gaze shift phenomenon may in fact be a systematic, albeit complex, relationship. However, even if subject differences do prove to moderate the relationship between type of question and gaze shift, the nature of that relationship may still be obscure. For example, since field-dependent and field-independent Ss differ in both cognitive and social behavior (Witkin et al., 1962), the possible presence of the field dependence dimension as a moderator variable does not necessarily decrease the number of theoretical options available.

Stares

In two of the three experiments, spatial questions elicited significantly more stares than verbal questions. These "stares" appear to be qualitatively different from those observed for questions which do not require reflective thought (e.g., "How much is two plus two?", Duke, 1968), since none of the present questions involved the kinds of over-learned responses which characterize the latter type of question.

These differences in the number of stares raise the issue as to whether or not stares constitute a separate class of behavior from gaze shifts. In these experiments, we computed the center of mass using as our N the number of scorable gaze shifts, so that, for example, a person with 40 scorable gaze shifts all at the "3" position would receive the same center of mass score as one who had 30 scorable gaze shifts all at the "3" position. An alternative procedure would be to compute the center of mass using as N the number of gaze shifts plus the number of stares. This would result in scores which would differentiate the hypothetical

persons described above. More generally, the fact that stares are sensitive to type of question suggests that extent of gaze shift (of which stares may be a special case) might prove important in studying the effect of type of question on gaze shifts. An alternative interpretation of stares, however, is that they are part of a general phenomenon of reduced ocular motility for spatial relative to verbal questions (Weiner & Ehrlichman, in preparation), and are unrelated to extent of gaze shift. Because the nature of the relationship between stares and gaze shifts is unclear at this point, it is probably best to compute centers of mass excluding stares.

Conclusion

At this point, the effects of verbal and spatial questions on the direction of initial gaze shifts appear to be reliable only for the vertical and not for the horizontal dimension. This fact has several implications. First, the idea that asymmetrical hemispheric activation by different types of questions is responsible for differences in the direction of gaze shifts (either within subjects as proposed by Kinsbourne and Kocel et al. or between subjects as proposed by Bakan) receives no support from the present data. Second, it is obviously premature to use the direction of initial gaze shifts as an indicator of ongoing cognitive process, as we had originally planned: the effect of verbal and spatial questions on horizontal gaze shifts is unreliable, and although the effect on vertical gaze shifts appears to have the requisite stability, there is yet to be developed a convincing theory linking vertical gaze shifts to cognitive process.

The present data clearly indicate that research on initial gaze shifts in response to questions should not be limited to the lateral direction of gaze shifts. Moreover, any theory attempting to explain the effects of type of question on gaze shifts must deal with the entire spectrum of results, including the stable differences in the vertical dimension between verbal and spatial questions, the failure of some "verbal" questions to yield the effect, the possible impact of subject variables on horizontal gaze shifts, and perhaps, the differences between verbal and spatial questions in the amount of stares which they elicit.

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Footnotes

[1]This research was carried out while the first two authors were postdoctoral fellows supported jointly by Educational Testing Service and NIH Grant MH 08260.

[2]The authors thank David Galin and Marcel Kinsbourne for making the questions used in their studies available. Thanks are also due to Ralph Garzio, Deena Hullman, and Laraine Schwartz for their help in carrying out this study and to Elizabeth Ehrlichman, Donald Goodenough, William Ward and Herman Witkin for comments on an earlier draft of the paper.

[3]Four questions similar to ones used by Kocel et al. which required S to hum musical phrases were also included in the spatial set.

[4]Interrater reliability was assessed by counting the number of trials on which the two Es scored the gaze shift in exactly the same way (i.e., both "2s," or "stares," or "no contacts"), and by counting the number of trials on which both Es observed a gaze shift but differed in the score they assigned by one clock position (i.e., where one E scored a "2" and the other a "3," but not where one scored a "2" and the other scored a "no contact"). The mean number of trials out of 80 in which Es agreed exactly was 55.4; the mean number out of 80 in which Es disagreed by one position was 14.2. Note that this is the rate of agreement prior to reviewing the video tape and correcting discrepancies. Es usually did not score a gaze shift unless they were fairly confident of its position (rather, they noted the trial as one to check on subsequently) since it was known that the video tape was available. Thus, this rate of agreement probably represents an underestimate of the interrater reliability.

[5]The authors thank Donald B. Rubin, Educational Testing Service, for his valuable help in working out the center of mass summary score.

[6]The samples were those from Ehrlichman, 1972, and Experiment I of the present study.

[7]Other ways of classifying Ss were unrelated to differences between verbal and spatial questions. Neither sex of S, overall tendency to shift gaze to the right or left, or overall tendency to shift gaze upward or downward significantly affected the verbal minus spatial difference on either the X or Y component.

Table 1

Mean X (Horizontal) and Y (Vertical) Components for Verbal and Spatial Questions in Experiment I

Type of Question	Components of Centers of Mass			
	X		Y	
	Mean	S.D.	Mean	S.D.
Verbal	+.096	.544	-.156	.312
Spatial	+.066	.584	+.006	.289
Verbal minus spatial	+.030	.212	-.162	.248

Note.--On the X component for type of question, + = leftward gaze shift, - = rightward gaze shift; on the Y component, + = upward gaze shift, - = downward gaze shift.

Table 2

Mean X (Horizontal) and Y (Vertical) Components for Verbal and Spatial Questions in Experiment II

Type of Question	Components of Centers of Mass			
	X		Y	
	Mean	S.D.	Mean	S.D.
Verbal	+.099	.450	-.235	.252
Spatial	+.033	.479	-.096	.252
Verbal minus spatial	+.066	.233	-.139	.176

Note.--On the X component for type of question, + = leftward gaze shift, - = rightward gaze shift; on the Y component, + = upward gaze shift, - = downward gaze shift.

Table 3

Mean X (Horizontal) and Mean Y (Vertical) Components for Verbal and Spatial Questions in Experiment III by Source of Questions and Interview Condition

Type of Question	Components of Centers of Mass			
	X		Y	
	Mean	S.D.	Mean	S.D.
	Source of Questions: Kocel et al.			
Verbal	+.044	.564	+.012	.328
Spatial	+.014	.485	+.023	.354
Verbal minus spatial	+.030	.269	-.011	.242
	Source of Questions: Experiments 1 & II			
Verbal	-.012	.590	-.134	.324
Spatial	-.056	.596	+.009	.316
Verbal minus spatial	+.044	.334	-.143	.234
	Interview Condition: Video Camera			
Verbal	+.012	.528	-.102	.374
Spatial	-.021	.485	-.027	.359
Verbal minus spatial	+.033	.272	-.075	.283
	Interview Condition: Face-to-face			
Verbal	+.021	.623	-.020	.282
Spatial	-.020	.588	+.059	.304
Verbal minus spatial	+.041	.331	-.079	.206

Note.--All Ss were given the questions from both sources and were run under both interview conditions. On the X component for type of question, + = leftward gaze shift, - = rightward gaze shift; on the Y component, + = upward gaze shift, - = downward gaze shift.

Figure Caption

Fig. 1. Illustration of clock face scheme. This "S" is looking at position "2," a leftward and upward gaze shift.

12
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APPENDIX

Questions used in Experiments I, II, and III.

Verbal questions (Exps. I & II)

✓ = Used in Exp. III

✓	Name a word with three syllables.
✓	What is a word that rhymes with PARADE?
	What word is this the definition of: A PLANT USED IN THE MAKING OF PAPER.
✓	Briefly, what is the meaning of this common proverb: LET SLEEPING DOGS LIE.
✓	What word is this the definition of: FAIR AND IMPARTIAL ADMINISTRATION OF LAWS.
	There is something wrong with the following sentence. What is it? EVERY ONE OF THE ONE HUNDRED SOLDIERS WERE THERE IN THEIR UNIFORMS.
✓	Solve this problem: John is better than Phil, and Mike is worse than Phil. Who is worst?
✓	There is something wrong with the following sentence. What is it? THE MAN IS SIX FEET SHORT.
	What is the definition of the word CHARITY?
	What word is this the definition of: A CREATURE WHO IS THE PERSONIFICATION OF EVIL.
	What is the seventh word of the Pledge of Allegiance?
	What word is this a definition of: A TALL FLOWER WITH YELLOW PETALS AROUND A LARGE, DARK CENTER.
	Name a word whose first three letters are SYN.
✓	What word is this the definition of: A NARROW CYLINDER WITH LENSES AT BOTH ENDS.
✓	Briefly, what is the meaning of this common proverb: DON'T SWAP HORSES IN MID-STREAM.
✓	What is the definition of the word LICORICE?
	What word is this the definition of: SUCCESS IN ANY CONTEST INVOLVING THE DEFEAT OF AN OPPONENT.
✓	Briefly, what is the meaning of this common proverb: WHEN THE CAT'S AWAY THE MICE WILL PLAY.
	Solve this problem: Jim is better than Ted, and Ted is better than Bob. Who is best?
	Name four conjunctions.

Verbal questions (Exps. I & II)

✓ What is the definition of the word PENCIL

Name a word that starts with L and ends with D.

Name four prepositions.

Solve this problem: Greg is worse than Joe, and Steve is worse than Greg. Who is worst?

There is something wrong with the following sentence. What is it? IN THE MIDDLE OF HANGING OUT THE WASH, THE WIND BLEW DOWN THE CLOTHES LINE.

✓ What word is this the definition of: A YELLOW ELONGATED FRUIT.

✓ Briefly, what is the meaning of this common proverb: TOO MANY COOKS SPOIL THE BROTH.

What is the ninth letter of the alphabet?

What word is this the definition of: GOVERNMENT BY ONE-MAN RULE?

✓ There is something wrong with the following sentence. What is it? HE WILL DO IT YESTERDAY.

✓ What word is this the definition of: A RULE WHICH GUIDES CONDUCT.

✓ What is a word that rhymes with SOFT?

✓ Briefly, what is the meaning of this common proverb: A ROLLING STONE GATHERS NO MOSS.

What is the definition of the word STRENGTH?

✓ Briefly, what is the meaning of this common proverb: ONE TODAY IS WORTH TWO TOMORROWS.

What word is this a definition of: A LARGE SPOTTED ANIMAL WITH A LONG NECK.

What word is this the definition of: A DAIRY PRODUCT OFTEN EATEN BY PEOPLE ON DIETS.

✓ Solve this problem: Al is worse than Sam, and Al is better than Rick. Who is best?

✓ Name a two-syllable word with the stress on the last syllable.

What word is this the definition of: A MEAT-EATING ANIMAL NATIVE TO INDIA.

If you connect the opposite corners of an octagon (that is, the shape of a stop sign) how many triangles do you get?

If a person is facing the rising sun, where is south with respect to him?

Solve this problem: there is a cube whose top and bottom surfaces are blue, left and right sides are red, and front and back surfaces are yellow. If this cube is flipped onto its front surface towards you, what color is the top surface now?

Hum the part of the Star Spangled Banner beginning with the words WHAT SO PROUDLY WE HAILED.

✓ What other letter do you get by turning a lower-case printed n upside-down?

Which president's face appears on a quarter?

If you are standing facing a wall and then make a 3/4 turn to the left, another 1/2 turn to the left and then a 1/4 turn to the right where is the wall with reference to yourself?

✓ If you cut a paper cylinder length-wise and then lay it out flat, what shape is the resulting figure?

✓ How many right-angles are there in a printed capital E?

✓ Try to form a mental picture of what I am going to tell you and tell me when the picture is as clear as you can get it: a poodle.

✓ In pictures of Napoleon, which hand does he hold in his coat?

✓ Describe the route by which you came to ETS today.

✓ If you place two equilateral triangles side by side what other standard geometric figures would you obtain?

✓ How many angles are there in the Red Cross symbol?

What direction of the compass does the front door of your house or apartment face?

If you are facing the front of a square house, and then walk 3/4 of the way around it to the right, and then 1 1/4 of the way around to the left, how far to the right do you then have to go to get to the front of the house?

✓ Try to form a mental picture of what I am going to tell you and tell me when the picture is as clear as you can get it: a forest.

Spatial questions (Exps. I & II)

If you draw a line from each of the upper two corners of a square to the mid-point of the bottom line of the square, what three figures result?

Try to form a mental picture of what I am going to tell you and tell me when the picture is as clear as you can get it: President Nixon's face.

What is the color of the top stripe of the American flag?

In which direction does Abraham Lincoln face on a penny?

Try to form a mental picture of what I am going to tell you and tell me when the picture is as clear as you can get it: an ocean liner.

What other letters can you get by rotating or flipping a lower case printed p.

How many line segments are there in a five-pointed star?

Tell me how many doorknobs there are in your house or apartment.

How many rows of keys are there on a typewriter?

Describe how one would go from the kitchen to the front door of your house or apartment.

In which hand does the Statue of Liberty hold the torch?

How many corners are there in a solid cube?

If you are sitting up in your bed, which part of your house or apartment is to your right?

Name two lower case letters which go below the line of print like the letters p and y.

Which way does Jefferson face on a nickel?

Tell me how many windows there are in your house or apartment.

Name three states that border on the Gulf of Mexico.

Hum the first phrase of HAPPY BIRTHDAY.

Solve this problem: if a capital Z is turned upside-down and then rotated to the left 90 degrees (that is, onto its side), what will the resulting figure look like?

Spatial questions (Exps. I & II)

✓ Name two numbers which look the same when written on a page or reflected in a mirror.

If you are the minister at a wedding, on which side of you does the bride stand?

Hum this melody after I do: (E hums first phrase of La Marseillaise). Exp. I only

Hum this melody after I do: (E hums "Big Ben"). Exp. I only

Which angle is greater: the smaller angle formed by the hands of a clock at 2:45 or the smaller angle formed by the hands of a clock at 2:30? Exp. II only

Which angle is greater: the smaller angle formed by the hands of a clock at ten after eleven or the smaller angle formed by the hands of a clock at twenty after eight? Exp. II only

Verbal questions (Kocel et al., Exp. III)

Divide 486 by 9.

Tell me four verbs beginning with "N."

Make up a sentence using two different tenses of two different verbs.

Multiply 341 x 11.

Spell "therapeutic."

Find 3/4 of 64.

List four adverbs.

Think of a word beginning with W and ending with F.

Decline or give the different forms of the verb "to be."

Define "inflation."

Solve the following arithmetic problem: 144/6 x 4 .

Make up a sentence using two forms of the same verb.

Define the word "economics."

Multiply 123 x 7 .

Tell me five verbs beginning with "R."

Name four parts of speech.

Make up a sentence using two adverbs.

Think of a word beginning with L and ending with C.

Say the first phrase of the Pledge of Allegiance backwards (prompt first line)

List four prepositions.

Give the tune of "Happy Birthday" without words.

Hum the tune of "Rudolph the Red-Nosed Reindeer."

Imagine the face of a smiling man/woman and try to make him/her as clear as possible.

Picture a nickel and tell me which way Jefferson is looking

Position a cone so that the point is downwards and place a sphere within the circular opening. What popular food do you now have the shape of?

Hum the tune of the "Wedding March."

The American flag is always pictured with the blue field on one side. Which is it?

Which of the continental United States border on the Pacific?

Hum "Row, Row, Row Your Boat."

If you are the minister at a wedding which side of you does the bride stand on?

Imagine all the rooms of your house and tell me how many windows you have.

In which hand does the Statue of Liberty hold a torch?

Imagine the face of a serious man/woman, making him/her as clear as possible.

There is a profile of George Washington on a quarter. Which way does he face?

Imagine a rectangle. Divide it in half by drawing a line from the upper left hand corner to the lower right. What two figures do you now have?

Hum or go "da, da, da" to suggest the sound of the theme for the "Lone Ranger."

Try to picture all the doors in your house and tell me how many door knobs there are.

Imagine the sequence of colors in the spectrum and the rainbow. Are the sequences the same?

Which way does Abraham Lincoln face on a penny?

Which angle is greater: the smaller angle formed by the hands of a clock at 2:45 or the smaller angle formed by the hands of a clock at 2:30?*

*This question was substituted for the one below which was deemed too ambiguous.

Visualize a box with a horizontal line drawn from one side to the other through the center and a circle with a diameter the same length as that line. Which figure enclosed the greater area?